

BRAZIL'S COMPETITIVENESS IN EXPORTATION OF FOREST PRODUCTS FROM 2008 TO 2018

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ABSTRACT – This article aims to analyze Brazil's global competitiveness in the exportation of forest products from 2008 to 2018. Data on importation and exportation were obtained from the Food and Agriculture Organization of the United Nations - FAO, while Revealed Comparative Advantage (RCA), Contribution to Trade Balance (CTB), and Terms of Trade (TOT) were the indicators used to measure international trade. The main results show that Brazil has a positive trade balance for forest products, mainly for wood pulp exports. Brazil's RCA for forest products was classified as moderate to strong. As for the forest product groups, it was strong for wood pulp, weak to moderate for wood panels, weak for paper and paperboard, weak to non-expressive for timber, and non-expressive for industrial roundwood and wood fuel. Based on Brazil's CTB, all the forest product groups have a comparative advantage, except wood fuel. Brazil's TOT was strong for wood panels, timber, industrial roundwood, wood pulp, in order from most to least expressive. In conclusion, Brazilian exports have comparative advantages and are competitive in the international market.

Keywords: Forest economics; Competitiveness indicators; Balance of trade.

COMPETITIVIDADE BRASILEIRA DAS EXPORTAÇÕES DOS PRODUTOS FLORESTAIS, DE 2008 A 2018

RESUMO – Este artigo tem por objetivo analisar a competitividade brasileira das exportações dos produtos florestais, de 2008 a 2018. Os dados de importações e exportações de produtos florestais foram obtidos da Food and Agriculture Organization of the United Nations – FAO e para mensurar o comércio internacional utilizou os indicadores Vantagem Comparativa Revelada (VCR), contribuição ao saldo comercial (CSC) e Taxa de Cobertura (TC). Os principais resultados mostraram que o Brasil possui superavit na balança comercial de produtos florestais, sendo as exportações de celulose o principal. O VCR brasileiro de produtos florestais foi classificado de moderada a forte e, entre os agregados de produtos florestais, a celulose foi forte, os painéis de madeira de fraco a moderado, papel e papelão fraco, madeira serrada de fraco a não expressivo e a madeira industrial e madeira para energia não expressivo. Por meio do CSC brasileiro de produtos florestais, todos agregados possuem vantagem comparativa, com exceção da madeira para energia. O TC brasileiro foi forte para painéis de madeira, madeira serrada, madeira industrial, celulose, sendo os mais expressivos em ordem decrescente, respectivamente. Conclui-se que as exportações brasileiras apresentam vantagens comparativas e tem competitividade no mercado internacional.

Palavras-Chave: Economia Florestal; Indicadores de Competitividade; Balança comercial.



1. INTRODUCTION

Brazil's forestry sector is gaining increasing visibility in the global market. Brazil is a tropical country with an extensive forest area (498,000 ha), accounting for 58% of the national territory. Fast-growing forest plantations (planted forests, which are sources of various products, byproducts, and services and generate employment and income and make an ecological contribution) account for nearly 2% of the forest cover. Eucalyptus wood goes into the production of wood pulp, furniture, boards, among other products and shows great potential. The Brazilian Tree Industry (IBÁ) represents the sector of trees grown for industrial purposes, which includes wood floors and panels, paper, wood pulp, timber, and charcoal. In 2018, the Gross Domestic Product (GDP) of Brazil was R\$ 7.0 trillion, with the forestry segment accounting for 1.3% of the national GDP and 6.9% of the industrial GDP. The sector provides nearly 3.8 million direct and indirect jobs. Compared to the performance of the agricultural and livestock sector (4.34% of GDP), the planted tree segment alone represents around 1/3, which plays a significant role in Brazil's economy (Indústria Brasileira de Árvores - Ibá, 2016; 2019; Serviço Florestal Brasileiro - Sfb, 2019).

Beginning in the 21st century, the advent of globalization led to a gradual increase in the internationalization of companies and intensifying technological innovation in the economy, making it essential to understand the competitive relationships of countries. Economic integrations, which are associated with the formation of economic blocks, create new relations in international trade. Meanwhile, enhancing the efficient instrumentalization of these relationships depends primarily on competitiveness and prior understanding of the market (Coelho Junior et al., 2013). Brazil's rise in forestry exports is based on sustainability, competitiveness, and innovation, which have become a reference in the world. The success of the Brazilian forestry sector can be attributed to strong market demand, increasing exports, and the rising sales price of forest products, especially commodities such as wood pulp and timber. The exportation of forest product has grown over the years. Since 2012, it has expanded at an average annual rate of 8.35%, reaching a record US\$ 11.4 billion in 2018 (Ibá, 2016; 2019; Sfb, 2019).

In a broader sense, competitiveness is considered a country's ability to increase its income and employment through the production of goods and services that compete in international markets (Fagerberg, 1988, Krugman, 2001). For the Organisation for Economic Cooperation and Development (OECD), competitiveness is a measure of a country's advantage or disadvantage in selling its products in international markets (OECD, 2014). Competitiveness is associated with a nation's exportation performance and its participation in international trade, and businesses with comparative advantage in a sector tend to be more productive in global terms. Competitiveness indicators provide the empirical elements needed to analyze the forest industry's structure and show the dimension of competitiveness of countries that export forest products. They help orient public policies and decision making. These indicators synthesize multiple dimensions, such as supply and demand, technological capacity, cost structure, innovation, value addition, among others, into one concept (Alcalá, 2016; Coelho Junior, 2016; Maxir and Masullo 2017, Selvatti et al. 2018).

In forest science literature, global competitiveness has been assessed by the following authors: Carvalho et al. (2009) analyzed Brazilian wood pulp and its main competitors; Petruski et al. (2012) examined Brazilian timber; Soares and Silva (2013) evaluated Brazilian extracted plant products; Parobek et al. (2016) investigated the forest products of Central European countries in the European Union (EU) and the impasses of Slovakia; Maxir and Masullo (2017) studied the introduction of Brazilian forest products in China; Schirigatti et al. (2018) observed Brazilian and Argentine mate; Souza et al. (2018) looked at Brazilian tropical timber in the global market; Ahmad et al. (2021) considered the exportation of forest products to Pakistan.

The Brazilian forestry sector nevertheless has many management barriers to overcome and requires more market knowledge and public policies to mobilize the production of forest products. Despite the advances made and the growth of forest product exports, problems exist hindering the competitiveness of the forest products supply chain. To understand the degree of competition in Brazil's forestry sector, this article analyzed the competitiveness of Brazilian forest product exports.

2. MATERIALS AND METHODS

2.1. Object of study

For this study, the monetary values, in US dollars (US\$), of Brazil's forest product imports and exports from 2008 to 2018 were obtained from the Statistics Division of the United Nations Food and Agriculture Organization - FAOSTAT. This period was chosen based on the availability of more recent data and on the understanding that 10 years is representative. Following the systematization of FAO (2020), forest products were grouped as follows to facilitate data analysis and interpretation: 1. Wood panels, 2. Wood pulp, 3. Wood fuel, 4. Timber, 5. Paper and paperboard, 6. Industrial roundwood.

The top 10 importing and exporting countries of forest products in the international market in 2018 were examined to demonstrate Brazil's participation and the progress of the country's balance of trade. To infer changes in the behavior of the variables, the geometric growth rate (*GGR*) (Equation 1) was used

$$GGR[\%] = \left[\sqrt[\Delta t]{\frac{V_t}{V_0}} - 1 \right] * 100 \quad \text{Eq.1}$$

where V_t represents wood production for the final year in t ; V_0 refers to wood production for the initial year; Δt is the interval of time for production (expressed in years) (Coelho Junior et al., 2022).

2.1. Competitiveness indicators

The indicators to measure competitiveness can be absolute or relative. Absolute indices compare a country's competitive performance with that of its competitors in the global trade of the respective products, while relative indices measure the relationship between the performance of the sector in question and the performance of other sectors in the same country (Petrauski et al., 2012). We evaluated Brazilian competitiveness and identified the forest products that perform best in global trade with the following indicators: revealed comparative advantage (RCA), contribution to trade balance index (CTB), and terms of trade (TOT).

2.2.1. Revealed comparative advantage

This second group of indicators has a relative bias and is inherent to the concept of revealed comparative advantage developed by Balassa (1965). For Balassa (1965), it would not be simple to quantify the factors

that account for the comparative advantages of nations because of the relative costs involved. Therefore, the author suggests that studies should be conducted in a way that reveals the advantages in the manner of trade. For a given country, the Revealed Comparative Advantage (RCA) indicator can then be interpreted as the association between a specific sector's participation in foreign trade and its participation in the total volume of exports of the country's manufacturing industry (Petrauski et al., 2012).

The revealed comparative advantage index (RCA) determines the sectors in a country that have a comparative advantage (Equation 2) and shows how competitiveness develops after trading. The indicator is interpreted as the ratio between the participation of a set of countries in the export market for forest products and their participation in total exports (Balassa, 1965),

$$CA = \frac{\frac{X_{kp}}{X_{pt}}}{\frac{X_{kw}}{X_{wt}}} \quad \text{Eq.2}$$

where X_{kp} = the value of forest product exports "k" from country "p" in the period; X_{pt} = the value of total exports from country "p" in period "t"; X_{km} = the value of forest product exports "k" in the world "w"; X_{wt} = the value of total exports in the world "w" in period "t." We adopted the classification proposed by Hinloopen and Van Marrewijk (2001), where a value less than or equal to one represents a non-expressive comparative advantage in forest product exports (1) (RCA ≤ 1). In cases where the revealed comparative advantage is weak, RCA is greater than one but less than or equal to two (1 < RCA ≤ 2). There is a moderate comparative advantage when RCA is greater than two but less than or equal to four (2 < RCA ≤ 4). When RCA is greater than four (RCA > 4), it indicates a strong revealed comparative advantage in Brazilian forest product exports.

2.2.2. Contribution to trade balance

The contribution to trade balance index (CTB) helps identify export specialization (Equation 3) by comparing the theoretical trade balance of the forest product in question and its observed balance (Soares and Silva, 2013; Silva, 2017),

$$CTB = \frac{100}{(X+M)} \left[(X_i + M_i) - (X - M) \frac{(X_i + M_i)}{(X + M)} \right] \quad \text{Eq.3}$$

Table 1 – Top 10 importing and exporting countries of forest products in the world in 2018, expressed in billions of dollars (US\$ x10⁶).
Tabela 1 – Os Top 10 países importadores e exportadores de produtos florestais no mundo, em bilhões de dólares (US\$ x10⁶), de 2018.

	Export	Import
1	United States of America	China
2	Canada	United States of America
3	Germany	Germany
4	China	Japan
5	Finland	United Kingdom
6	Sweden	Italy
7	Russia	France
8	Brazil	India
9	Indonesia	South Korea
10	Áustria	Mexico
Top 10	158.46	Top 10
Rest of the world	103.97	Rest of the world
World	262.43	World

Source: FAO (2020).

Fonte: FAO (2020).

where X_i = the country's exports of product "i"; M_i = the country's imports of "i"; X = the country's total exports; M = the country's total imports. The first term before the brackets represents the observed trade balance of forest product "i" and the second term, which is in the brackets, represent the theoretical trade balance for forest product "i." If CTB is positive, there is comparative advantage, and if it is negative or equal to zero, there is no comparative advantage. CTB compares the trade balance for a particular product (or a group of goods) with the theoretical trade balance for that item and evaluates a company's competitiveness based on trade in the sector and in the country. The trade balance alone is not enough to examine the progress of specializations: the industry's competitiveness also depends on the progress of

Source: FAO (2020).

Fonte: FAO (2020).

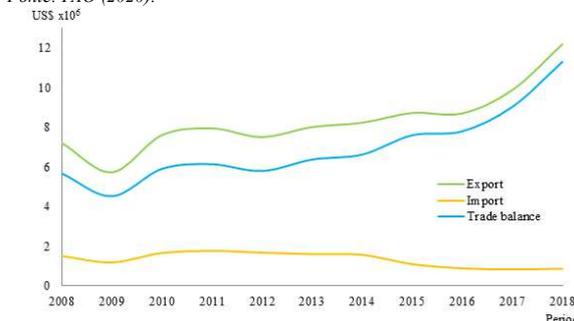


Figure 1 – Progress of the Brazilian trade balance for forest products from 2008 to 2018, expressed in billions of dollars (US\$ x10⁶).

Figura 1 – Evolução da balança comercial brasileira de produtos florestais, em bilhões de dólares (\$ x10⁶ USD), de 2008 a 2018.

Table 2 – Progress of the revealed comparative advantage (RCA) of Brazilian forest products from 2008 to 2018.

Tabela 2 – Evolução da vantagem comparativa revelada de produtos florestais brasileiro, de 2008 a 2018.

Year	Wood panels	Cellulose	Wood fuel	Sawn wood	Paper and paperboard	Industrial roundwood	Forest products
2008	2,17	10,56	0,00	1,85	1,29	0,04	2,62
2009	1,61	12,03	0,00	1,45	1,43	0,01	2,69
2010	1,51	10,76	0,00	1,12	1,41	0,04	2,70
2011	1,14	9,86	0,0004	0,94	1,31	0,08	2,39
2012	1,43	10,48	0,0005	0,87	1,35	0,1	2,53
2013	1,42	11,61	0,0004	0,79	1,36	0,08	2,64
2014	1,61	12,94	0,0005	0,97	1,42	0,14	2,85
2015	1,97	14,84	0,0006	1,23	1,74	0,21	3,50
2016	2,26	15,79	0,0031	1,42	1,64	0,26	3,59
2017	2,56	15,26	0,00	1,51	1,54	0,28	3,60
2018	2,85	16,55	0,00	1,69	1,47	0,34	4,10
Average	1,87	12,79	0,00	1,26	1,45	0,14	3,02
GGR (%)	2,76	4,60	0,00	-0,90	1,31	23,86	4,58

Obs. GGR = geometric growth rate.

Source: The authors.

Obs. GGR = Taxa Geométrica de Crescimento.

Fonte: Os autores.

Table 3 – Progress of the contribution to trade balance index (CTB) for forest products exported by Brazil from 2008 to 2018.
Tabela 3 – Evolução do índice de contribuição ao saldo comercial brasileiro de produtos florestais, de 2008 a 2018.

Year	Wood panels	Cellulose	Wood fuel	Sawnwood	Paper and paperboard	Industrial roundwood	Forest products
2008	0,29	1,59	0,00	0,29	0,25	0,0022	2,49
2009	0,21	1,71	0,00	0,21	0,35	-0,0013	2,54
2010	0,19	1,85	-0,000005	0,17	0,27	0,0018	2,53
2011	0,13	1,53	-0,000001	0,13	0,23	0,0052	2,07
2012	0,17	1,5	-0,000004	0,11	0,2	0,0054	2,04
2013	0,18	1,68	-0,000006	0,12	0,25	0,0054	2,28
2014	0,22	1,84	-0,000006	0,15	0,28	0,0105	2,54
2015	0,28	2,27	-0,000014	0,18	0,49	0,0132	3,31
2016	0,33	2,37	-0,000011	0,22	0,47	0,0171	3,48
2017	0,36	2,39	0,00	0,25	0,39	0,0188	3,47
2018	0,4	2,93	0,00	0,27	0,38	0,0224	4,08
Average	0,25	1,97	0,00	0,19	0,32	0,01	2,80
GGR (%)	3,27	6,30	0,00	-0,71	4,28	26,12	5,06

Obs. GGR = geometric growth rate.

Source: The authors.

Obs. GGR = Taxa Geométrica de Crescimento.

Fonte: Os autores.

Table 4 – Progress of the terms of trade (TOT) ratio of Brazilian forest products from 2008 to 2018.

Tabela 4 – Evolução da taxa de cobertura (TC) de produtos florestais brasileiras, de 2008 a 2018.

Year	Wood panels	Cellulose	Wood fuel	Sawnwood	Paper and paperboard	Industrial roundwood	Forest products
2008	8,50	14,73	0,00	37,43	0,60	4,69	4,74
2009	9,55	14,45	0,00	25,91	0,63	0,32	4,82
2010	8,01	13,91	0,00	28,37	0,59	3,20	4,53
2011	5,98	14,06	0,09	21,73	0,60	8,01	4,45
2012	10,46	14,87	0,17	15,55	0,58	9,32	4,44
2013	11,31	16,11	0,13	18,74	0,59	9,44	4,95
2014	18,36	16,14	0,13	16,16	0,59	17,68	5,19
2015	50,34	17,26	0,08	15,09	0,72	22,09	7,93
2016	114,78	21,44	0,41	15,41	0,75	37,63	9,86
2017	113,23	41,03	0,00	45,15	0,73	37,96	11,92
2018	138,48	52,27	0,00	52,85	0,73	93,17	14,1
Average	44,45	21,48	0,09	26,58	0,65	22,14	6,99
GGR (%)	32,19	13,50	0,00	3,51	1,98	34,84	11,52

Obs. GGR = Geometric growth rate.

Source: The authors.

Obs. GGR = Taxa Geométrica de Crescimento.

Fonte: Os autores.

Table 5 – Evolução dos pontos fortes, fracos e neutralidade relacionado às exportações Brasileiras de produtos florestais, de 2008 a 2018.

Tabela 5 – Evolução dos pontos fortes, fracos e neutralidade relacionado às exportações Brasileiras de produtos florestais, de 2008 a 2018.

Year	Wood panels	Cellulose	Wood fuel	Sawnwood	Paper and paperboard	Industrial roundwood	Forest products
2008	Strong	Strong	Weak	Strong	Neutral	Neutral	Strong
2009	Strong	Strong	Weak	Strong	Neutral	Weak	Strong
2010	Strong	Strong	Weak	Strong	Neutral	Neutral	Strong
2011	Strong	Strong	Weak	Neutral	Neutral	Neutral	Strong
2012	Strong	Strong	Weak	Neutral	Neutral	Neutral	Strong
2013	Strong	Strong	Weak	Neutral	Neutral	Neutral	Strong
2014	Strong	Strong	Weak	Neutral	Neutral	Neutral	Strong
2015	Strong	Strong	Weak	Strong	Neutral	Neutral	Strong
2016	Strong	Strong	Weak	Strong	Neutral	Neutral	Strong
2017	Strong	Strong	Weak	Strong	Neutral	Neutral	Strong
2018	Strong	Strong	Weak	Strong	Neutral	Neutral	Strong

Source: The authors.

Fonte: Os Autores.

domestic demand and ultimately on GDP (Maksymets and Lönnstedt, 2016).

2.2.3. Terms of trade

Along with the comparative advantage index, the terms of trade (TOT) ratio helps determine the economy's strengths and weaknesses (Soares and Silva, 2013; Silva, 2017). TOT (Equation 4) is the ratio of exports to imports,

$$TOT = \frac{X_i}{M_i} \quad \text{Eq.4}$$

where TOT = terms of trade; X_i = exports of product "i" to region or country "j"; M_i = imports of product "i" from region or country "j." There is a contribution to the balance of trade if the terms of trade ratio are higher than one (1), when exports exceed the import of a certain product, thus contributing to the surplus of a specific region. In this analysis, when the interaction of a product's *RCA* and *TOT* indices is higher than the units, it is considered to be a strong point of an economy, but if these values are less than one, it is deemed to be a weak point. A comparison of these points can identify the trade potential of forest products (Maksymets and Lönnstedt, 2016).

3. RESULTS

Table 1 presents the top 10 importing and exporting countries of forest products in the world in 2018, expressed in billions of dollars (US\$ x10⁶).

Figure 1 presents the progress of the Brazilian trade balance for forest products from 2008 to 2018, expressed in billions of dollars (US\$ x10⁶).

Table 2 presents the progress of the revealed comparative advantage (RCA) of Brazilian forest products from 2008 to 2018.

Table 3 presents the progress of the contribution to trade balance index (CTB) for forest products exported by Brazil from 2008 to 2018.

Table 4 presents the progress of the terms of trade (TOT) ratio of Brazilian forest products from 2008 to 2018.

Table 5 presents the progress of strengths and weaknesses related to Brazilian forest product exports from 2008 to 2018.

4. DISCUSSION

As shown in Table 1, global exports of forest products reached US\$ 262.43 x10⁶, and the top 10 exporting countries of forest products accounted for 60.38% (US\$ 58.46 x10⁶) of this total. The main countries were the United States (10.73%), Canada (9.71%), and Germany (8.55%), and Brazil ranked eighth, accounting for 3.83% (US\$ 10.04 x10⁶) of global exports. Global imports of forest products reached US\$ 283.41 x10⁶, and the top 10 importing countries of forest products represented 58.68% (US\$ 166.30 x10⁶). The main countries were China (20.17%), the United States (9.41%), and Germany, while Brazil (US\$ 0.87 x10⁶ USD) ranked 51st.

Although the global trade balance for forest products was negative in 2018 (US\$ -20.98 x10⁶), even in the top 10 (US\$ -7.8 x10⁶), Brazil had a balance of US\$ 11.32 x10⁶. As shown in Figure 1, the Brazilian trade balance for forest products from 2008 to 2018 increased at an average annual rate of 7.10%, so it was US\$ 2.07 x10⁶ in 2008. This increase in the balance was driven by the inversely proportional behavior of Brazilian exports and imports of forest products. While Brazilian exports presented an average annual growth of 5.36%, imports presented an annual drop of 5.51%. According to Coelho Junior et al. (2020), Mayr et al. (2020), and Oliveira et al. (2020), these advances are associated with the expansion of the Brazilian forest industry, which required readjusting and certifying the raw material base, and these industrial segments could establish some gains in competitiveness with comparative advantages. Therefore, it was necessary to focus and direct the investments toward productivity and quality so as to convert the comparative advantages of the forest resources planted in the country into more competitive advantages. In addition to other sectors of the economy, the Brazilian forestry sector is also dependent on the resources that the environment provides to society and has turned its attention to environmental preservation and to economic and social inequalities. Forest certification is a way to assure the consumer that a company follows a specific set of standards that are congruent with sustainable forest management.

According to Table 2, the RCA of forest products showed a moderate comparative advantage from

2008 (2.62) to 2017 (3.6) and became strong in 2018 (4.1), resulting in an average RCA of 3.02, a moderate comparative advantage demonstrating an upward trend at an average annual rate of 4.58%. This increase in the RCA can be attributed especially to the wood pulp group, which essentially remained with RCA indices of over 10. In general, the revealed comparative advantage of wood panels, paper and paperboard, and timber was weak. The RCA index of forest products and the groups increased in the period under analysis, with the exception of wood fuel, representing a gain in competitiveness in the export of all the products, particularly wood pulp and timber, in addition to the increase in sales prices, which in some way contributed to this result.

According to FAO (2020), Brazil was ranked as the second largest global exporter of wood pulp in 2018, behind only Canada and followed by the United States and Finland, which were placed third and fourth, respectively, in world ranking. Coelho Junior et al. (2018) found global wood pulp exports showed an upward trend of around 5.99% p.a. between 2001 and 2014, driven by a growing demand, population, and per capita consumption, and encouraged the addition of new exporting countries. The main destinations of Brazilian wood pulp exports were North America, Europe, and Asia. Brazilian "wood pulp" was the only group among the forest products whose revealed comparative advantage was strong, with an average RCA of 12.79 and a GGR of 4.60% p.a. from 2008 to 2018. Between 2010 (10.76) and 2013 (11.61), there was a small retraction in the RCA index, which reflected the global crisis arising from the crash of the North American real estate sector that directly affected the United States market (one of the largest producers of wood pulp). This increased Brazilian competitiveness in the international market, and as of 2014, owing to currency devaluation, the RCA recovered higher values than in 2009 (Ibá, 2014, 2019, Coelho Junior et al., 2018).

Wood panels were the second most competitive forest product group among the others with a growth of 2.76% p.a. However, its average revealed comparative advantage (1.87) was weak from 2008 to 2018 as the impact of the 2008 North American crisis was severe and the United States was the main importer of Brazilian wood panels. The RCA was classified as weak from 2009 to 2015 but began to recover as of

2012 and reached a moderate classification in 2016, which grew until 2018.

Paper and paperboard was the third most competitive group among the forest products. Its RCA rose from 1.29 (2008) to 1.69, demonstrating a GGR of 1.31% p.a. and an average RCA of 1.41, which is classified as weak competitiveness. The domestic paper industry grew from 2002 to 2012 driven by domestic and foreign demand and demonstrated a growing RCA, but the index was lower in 2011 (1.31) and gradually recovered in cycles of growth. Although the index rose between the years 2016 and 2018, Brazil ranked eighth in global paper production in the last year, and the index presented a retraction of approximately 0.4% from the previous year due to a 4.6% reduction in exports (Ibá, 2018, 2019).

The revealed comparative advantage of timber was weak, with an average RCA of 1.26 and a GGR of -0.9% p.a. From 2008 to 2010, the revealed comparative advantage of this forest product group was weak and non-expressive between 2011 and 2014, with a RCA of less than one. From 2015 to 2018, the RCA recovered somewhat but was weak. Despite the rising value of the indicator, it did not reach the index in 2008. Competitiveness appeared to improve as of 2015 driven by improvements in the international market and a 15.1% increase in Brazilian exports driven by the North American construction sector, despite the devaluation of the Brazilian real (R\$) against the dollar. These factors enabled the sector's effective performance during this period. The revealed comparative advantages of "wood fuel" and "industrial roundwood" were non-expressive (Ibá, 2014, 2018, 2019).

Table 3 allows us to identify the national forest product export specializations based on the results of the contribution to trade balance index (CTB). Brazil has comparative advantages in the export of wood panels, wood pulp, timber, paper and paperboard, so CTB assumes positive values throughout the period. The two products that were not competitive in the international market were wood fuel and industrial roundwood, whereas the latter was only competitive in 2009. Therefore, the products with comparative advantages (wood panels, wood pulp, timber, and paper and paperboard) also made significant contributions to the balance of trade, especially wood pulp. Brazil exhibited comparative advantages for

exportation in relation to the forest product groups throughout the period under study.

According to Table 4, the terms of trade ratio of Brazilian forest products was strong, with an average TOT of 6.99 and an average growth of 11.52% p.a. in the period (2008 to 2018), from 4.74 (2008) to 14.1 (2018). The main groups that contributed to this increase were wood panels, timber, industrial roundwood, and wood pulp. Wood panels had the highest average TOT with 44.45 and a GGR of 32.19% p.a., from 8.5% (2008) to 52.85% (2018). This indicates the gains in Brazil's exportation of this forest product. Timber ranked second with an average TOT of 26.58 and a GGR of 3.51% p.a., from 4.69% (2008) to 52.85% (2018). The lowest TOT was in 2015 (15.09), and 2018 registered the highest. The TOT ratio for industrial roundwood increased extraordinarily in comparison to the other groups, although the average TOT stood at 22.14, and its GGR was the highest (34.84% p.a.). Wood pulp already has a consolidated structure of production aimed toward the international market, presenting an average TOT of 21.48 and a GGR of 13.50% p.a. Wood fuel and paper and paperboard showed a weak terms of trade ratio as these forest product groups are produced to supply domestic demand.

Table 5 demonstrates competitiveness by means of the interaction of the RCA and TOT indices for the Brazilian forest product exports. Between 2008 and 2018, wood pulp and wood panels were classified as strongly competitive. From 2008 to 2010 and from 2015 to 2018, timber was also classified as strongly competitive. These forest product groups presented more exports than imports and contributed to the positive trade balance. Concurrently, they presented a comparative advantage for being specialized sectors in international trade. Wood fuel and industrial fuel demonstrated weak competitiveness. Industrial roundwood and paper and paperboard were neutral in relation to competitiveness. This may be explained by Brazil's enormous need to import these products. However, a higher level of processing or added value results in a weakness that hinders the national competitiveness of this sector in relation to the international market (Maxir and Masullo, 2017). Forest products whose terms of trade ratio are greater than the unit are the same that demonstrated greater comparative advantages for the RCA and CTB

indices. It is understood that these competitive forest products had comparative advantages and contributed to Brazil's positive trade balance simultaneously.

5. CONCLUSION

Based on the analyses, the United States is among the three largest global exporters and importers of forest products, and Brazil is in eighth position in the global ranking, and the international trade balance was negative in 2018. Brazil showed upward trends in trade surplus during the period under study, which were associated mainly with wood pulp exports. The RCA classification of Brazilian forest product exports ranged from moderate (2008 to 2017) to strong (2018). Among the forest product groups, wood pulp was strong; wood panels were weak to moderate; paper and paperboard were weak, timber was non-expressive to weak; and industrial roundwood and wood fuel were non-expressive. The forest products' contribution to the trade balance of Brazil showed that all the groups have a comparative advantage, with the exception of wood fuel. Wood pulp is strongly competitive and contributes to the positive trade balance of Brazilian forest products. The greatest TOT ratios with a strong classification were wood panels, timber, industrial roundwood, and wood pulp, in descending order. Comparative advantages were thoroughly assessed via competitiveness indicators to elucidate what drives Brazilian forest products to perform well or poorly. Future research should adopt other indicators, such as Revealed Symmetric Comparative Advantage and constant market share.

AUTHOR CONTRIBUTIONS

HFS, MLS and LMCJ contributed to the conception and the design of the study. HFS, MLS and LMCJ executed the methodology. HFS wrote the first draft of the manuscript. MLS, NSS, FFD and LMCJ supplemented and improved the manuscript.

All authors contributed to manuscript revision and read and approved the submitted version.

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